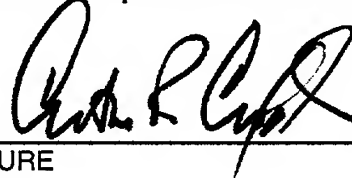


FORM PTC-1390 (REV 11-2000)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 124-917
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5) 10/048115 unknown
INTERNATIONAL APPLICATION NO. PCT/GB00/02837	INTERNATIONAL FILING DATE 26/07/2000	PRIORITY DATE CLAIMED 26/07/1999
TITLE OF INVENTION HYDROGEN PEROXIDE BASED PROPULSION SYSTEM		
APPLICANT(S) FOR DO/EO/US TILSTON, J. et al.		
<p>Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:</p> <ol style="list-style-type: none"> <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. <input checked="" type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below. <input checked="" type="checkbox"/> The U.S. has been elected by the expiration of 19 months from the priority date (Article 31). <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)). <ol style="list-style-type: none"> <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau). <input checked="" type="checkbox"/> has been communicated by the International Bureau. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). <input type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). <ol style="list-style-type: none"> <input type="checkbox"/> is attached hereto. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4). <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) <ol style="list-style-type: none"> <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). <input checked="" type="checkbox"/> have been communicated by the International Bureau. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. <input type="checkbox"/> have not been made and will not be made. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). <input type="checkbox"/> A English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). <p>Items 11 To 20 below concern document(s) or information included:</p> <ol style="list-style-type: none"> <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. <input checked="" type="checkbox"/> A FIRST preliminary amendment. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. <input type="checkbox"/> A substitute specification. <input type="checkbox"/> A change of power of attorney and/or address letter. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4). <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4). <input checked="" type="checkbox"/> Other items or information. PTO Form 1449, Intl. Search Report, Search Report under section 17(5) and 2 Cited References 		

U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.51) unknown 10/048115		INTERNATIONAL APPLICATION NO. PCT/GB00/02837		ATTORNEY'S DOCKET NUMBER 124-917	
21. <input checked="" type="checkbox"/> The following fees are submitted:				CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5): -- Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO\$1040.00 -- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO.....\$890.00 -- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO\$740.00 -- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4).....\$710.00 -- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4).....\$100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				\$	890.00
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).				\$	0.00
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	12	-20 =	0	X	\$18.00
Independent Claims	5	-3 =	2	X	\$84.00
MULTIPLE DEPENDENT CLAIMS(S) (if applicable)					\$280.00
CLAIM FEES ARE NOT BEING PAID AT THIS TIME					
TOTAL OF ABOVE CALCULATIONS =				\$	1058.00
<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.					0.00
SUBTOTAL =				\$	1058.00
Processing fee of \$130.00, for furnishing the English Translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)).					0.00
TOTAL NATIONAL FEE =				\$	1058.00
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property				+	\$
Fee for Petition to Revive Unintentionally Abandoned Application (\$1280.00 - Small Entity = \$640.00)					0.00
TOTAL FEES ENCLOSED =				\$	1098.00
				Amount to be:	
				refunded	\$
				Charged	\$
a. <input checked="" type="checkbox"/> A check in the amount of \$1098.00 to cover the above fees is enclosed. b. <input type="checkbox"/> Please charge my Deposit Account No. 14-1140 in the amount of \$_____ to cover the above fees. A duplicate copy of this form is enclosed. c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 14-1140. A duplicate copy of this form is enclosed. d. <input checked="" type="checkbox"/> The entire content of the foreign application(s), referred to in this application is/are hereby incorporated by reference in this application.					
NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO: NIXON & VANDERHYE P.C. 1100 North Glebe Road, 8 th Floor Arlington, Virginia 22201-4714 Telephone: (703) 816-4000					
				 SIGNATURE	
				Arthur R. Crawford NAME	
				25,327 REGISTRATION NUMBER	
				January 28, 2002 Date	

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

TILSTON, J. et al.

Atty. Ref.: 124-917

Serial No. unknown

Group:

Filed: January 28, 2002

Examiner:

For: HYDROGEN PEROXIDE BASED PROPULSION SYSTEM

* * * * *

January 28, 2002

Assistant Commissioner for Patents
Washington, DC 20231

Sir:

PRELIMINARY AMENDMENT

In order to place the above-identified application in better condition for examination, please amend the application as follows:

IN THE SPECIFICATION

Please substitute the following paragraphs in the specification for corresponding paragraphs previously presented. A copy of the amended specification paragraphs showing current revisions is attached.

Page 1, before the first line, insert as a separate paragraph:

This application is the US national phase of international application PCT/GB00/02837 filed 26 July 2000, which designated the US.

IN THE CLAIMS

Please substitute the following amended claims for corresponding claims previously presented. A copy of the amended claims showing current revisions is attached.

9. A method of propelling a micro air vehicle as claimed in claim 7.
12. A method of propelling a micro air vehicle as claimed in claim 10.

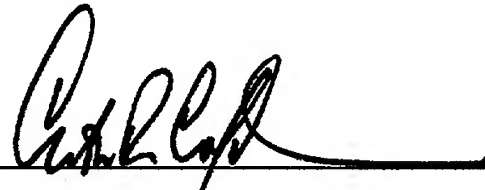
REMARKS

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page(s) is captioned "Version With Markings To Show Changes Made."

Respectfully submitted,

NIXON & VANDERHYE P.C.

By: _____


Arthur R. Crawford
Reg. No. 25,327

ARC:ecb
1100 North Glebe Road, 8th Floor
Arlington, VA 22201-4714
Telephone: (703) 816-4000
Facsimile: (703) 816-4100

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION

Page 1, before the first line, insert as a separate paragraph:

This application is the US national phase of international application

PCT/GB00/02837 filed 26 July 2000, which designated the US.

IN THE CLAIMS

9. A method of propelling a micro air vehicle as claimed in claims 7-~~or~~8.

12. A method of propelling a micro air vehicle as claimed in claims 10-~~or~~11.

10/04 8115
Rec'd PCT/PTO 28 JAN 2002Hydrogen Peroxide Based Propulsion System

The invention relates to hydrogen peroxide (H_2O_2) engines and in particular to a novel hybrid rocket/turbine hydrogen peroxide based engine and hydrogen peroxide based propulsion system for micro air vehicle propulsion.

Micro air vehicles (MAVs) play a key role in military and surveillance operations. For these MAVs, a range of engine characteristics is needed to meet specific requirements, such as low speed, low noise, high speed, etc. In this specification MAVs are defined as air vehicles which have a wingspan of 1 metre or less and/or a weight 2kg or less. Features such as weight, ease of starting, reliability, etc. are important in the choice of the power plant. Air breathing engines or motors are usually attractive on weight grounds because they do not have to carry their own oxidant. However this may not be so important at small scales when the mass of the engine itself is relatively high. In addition, of course, small engines have relatively poor thermal and propulsive efficiency due to low cycle temperatures.

Hydrogen peroxide engines are known. The inventors have determined that these engines can be built small enough and give adequate performance requirements for use in MAVs. Hydrogen Peroxide can nowadays be generated 'in the field' by electrolytic techniques. It can be decomposed catalytically to produce steam and oxygen at high temperature and is an acceptable propellant in its own right with a high specific thrust and a low infrared (IR) signature.

The invention comprises a micro air vehicle comprising tank adapted to contain hydrogen peroxide and connected to a region adapted to decompose hydrogen peroxide, a nozzle adapted to exit the decomposition products of hydrogen peroxide to provide thrust, means to provide a hydrocarbon fuel adapted to burn by consuming oxygen from the decomposition of hydrogen peroxide whereby the hydrogen peroxide is pressurised thus providing pressurised oxygen to pressurise said fuel.

Further is provided a method of propelling a micro air vehicle comprising decomposing hydrogen peroxide and exiting the decomposition products through a nozzle to provide thrust.

The invention also comprises a micro air vehicle having an engine having connection means to a tank adapted to contain hydrogen peroxide, a fuel tank connected to a region adapted to decompose hydrogen peroxide, a decomposition region/chamber suitable for decomposing hydrogen peroxide, a nozzle to accelerate the resulting decomposition products, a turbofan located downstream of the exit of said nozzle and located within a duct so as to provide propulsive thrust and means to provide a hydrocarbon fuel adapted to burn by consuming oxygen from the decomposition of hydrogen peroxide.

Preferably a hydrocarbon fuel is provided to consume oxygen from the decomposition of hydrogen peroxide. Preferably pressurised oxygen is used to pressurise said fuel.

The invention will now be described with by way of example only and with reference to the following figures of which:

Figure 1 shows an embodiment of the invention comprising combustion chamber/nozzle and a ducted fan.

In a simple embodiment of the invention, a MAV power plant 1 includes a fuel tank 2 containing 34g of H_2O_2 . To hold this weight of fuel, the fuel tank can be a simple cylinder (2cm in diameter and 7.5cm in length). The fuel tank alone will weigh about 16g if it is made of aluminium and its thickness (1mm) should be sufficient to contain the pressure inside the tank. The fuel tank is connected to a combustion chamber/nozzle 3 of weight less than 2g.

The decomposition of H_2O_2 is an exothermic process in which a substantial rise in temperature occurs. Thermodynamic calculations on a 90% H_2O_2 solution show that a

temperature of 1022K (749°C) and a pressure of 35.5bar (515psi) are achievable when the decomposition products are allowed to expand adiabatically to atmospheric pressure.

A simple convergent/divergent nozzle is used in the flow parameter calculations necessary to diminish the combustion chamber pressure and nozzle exit area. A chamber pressure of 2.07bar (30psi) and a nozzle exit diameter of about 2mm will produce a mass flow through the nozzle of about 0.17g/s and a nozzle exit velocity of M 1.1. The thrust produced now is about 0.124N which is comparable to the amount required to propel a MAV. A monopropellant (H_2O_2) propulsion system has the advantages of low exhaust temperature and simple equipment design.

In a preferred embodiment, a bipropellant system uses hydrocarbon fuel to consume the excess oxygen. This system uses an additional tank to store the hydrocarbon. This has a clear advantage in endurance over the monopropellant system. However, the gain in endurance must weigh against the increase in combustion temperature and complexity in the fuel system. At temperatures in excess of 2400K, very few materials will be suitable for making the combustion chamber. Also, very efficient cooling techniques must be implemented to avoid damage to the combustion chamber. Preferably the propulsion system utilises hydrogen peroxide and kerosene as fuel and oxygen as the oxidant. A bipropellant (H_2O_2 and kerosene) propulsion system has a 70% improvement on flight endurance but has high exhaust temperature (circa 2700K) which makes the design and selection of material for the combustion chamber/nozzle very challenging. A bipropellant system with on-board oxygen gives the best flight endurance.

In the most preferred embodiment the system comprises a bipropellant system as described above with the addition of a ducted fan. Such an arrangement is not known per se. Figure 1 shows a figure showing the arrangement 4 of a hydrogen peroxide based ducted fan engine comprising a decomposition chamber/nozzle arrangement 5, and a turbofan 6 comprising turbine 7 and fan 8 arranged within a duct 9. In the ducted fan engine design, air passes through the outside of the combustion chamber/nozzle. The front of the combustion chamber has to be shaped to avoid flow separation. The combustion chamber/nozzle will attain very high temperatures during operation and the bypass flow will help to cool the

nozzle. For a bypass ratio of 10, the duct exit flow velocity is found to be about 300m/s and the duct exit is 3mm in diameter. The fan rotational speed is estimated to be 1.63E6rpm. This is due to the small size of the fan. While these calculations are based on a nozzle throat area of 1mm diameter. The total thrust produced by this engine is 0.634N. Preferably a hydrocarbon based fuel is also burnt, at least in part using oxygen produced by the decomposition of hydrogen peroxide. The hydrocarbon may be burnt in the region of the nozzle.

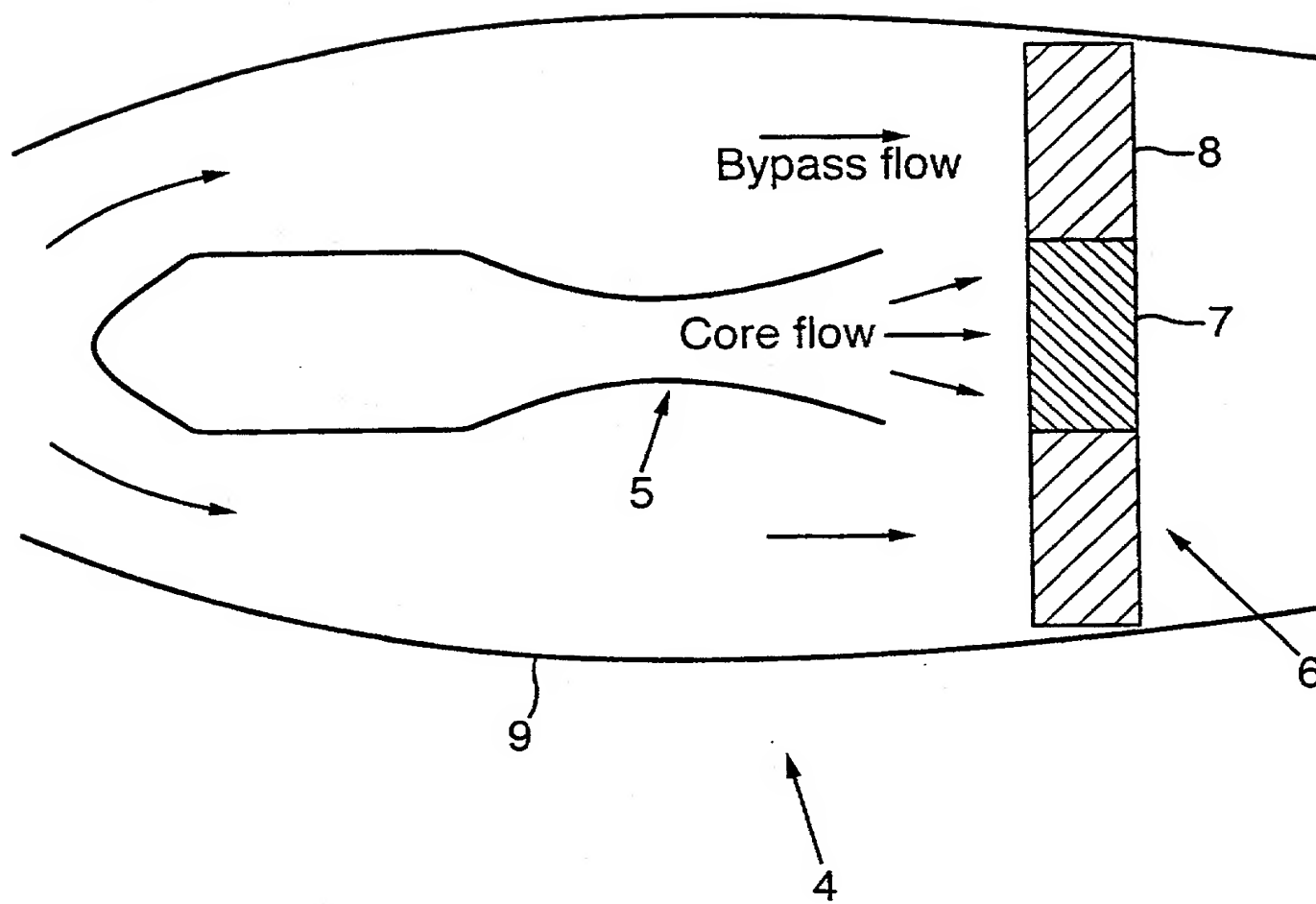
Considerations have been given to the utilisation of an on-board oxygen cylinder as a pressure source for fuel delivery of oxygen (2.4g at 137.93bar) will increase the flight endurance by 2.7 minutes (0.38mm throat) storage tank of radius 1cm and length 3cm.

2001-03-01

Claims

1. A micro air vehicle comprising fuel tank connected to a region adapted to decompose hydrogen peroxide, a nozzle adapted to exit the decomposition products of hydrogen peroxide to provide thrust, means to provide a hydrocarbon fuel adapted to burn by consuming oxygen from the decomposition of hydrogen peroxide and pressurised oxygen to pressurise said fuel.
2. A micro air vehicle comprising an engine having connection means to a tank adapted to contain hydrogen peroxide, a fuel tank connected to a region adapted to decompose hydrogen peroxide, a decomposition region/chamber suitable for decomposing hydrogen peroxide, a nozzle to accelerate the resulting decomposition products, a turbofan located downstream of the exit of said nozzle, and located within a duct so as to provide propulsive thrust and means to provide a hydrocarbon fuel adapted to burn by consuming oxygen from the decomposition of hydrogen peroxide.
3. An engine as claimed in claim 4 additionally comprising a means for providing hydrocarbon fuel to said decomposition region/chamber or nozzle to be oxidised at least in part by the oxygen produced by the decomposition.
4. A method of propelling a micro air vehicle comprising decomposing hydrogen peroxide and exiting the decomposition products through a nozzle to provide thrust.
5. A method as claimed in claim 4 including burning a hydrocarbon fuel with the oxygen produced from said combustion.
6. A method as claimed in claim 5 wherein said hydrocarbon is pressurised.
7. A method of propulsion comprising decomposing hydrogen peroxide and exiting the resulting said decomposition products through a nozzle towards a turbofan located with a duct.
8. A method as claimed in claim 7 wherein additionally comprising burning a hydrocarbon fuel with oxygen provided from decomposition.
9. A method of propelling a micro air vehicle as claimed in claims 7 or 8.

Fig.1.



RULE 63 (37 C.F.R. 1.63)
DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Hydrogen Peroxide Based Propulsion System

the specification of which (check applicable box(es)):

☐ is attached hereto

☐ was filed on _____

☒ was filed as PCT International application No. _____

and (if applicable to U.S. or PCT application) was amended on _____

as U.S. Application Serial No. _____

PCT/GB00/02837

on 26th July 2000

Atty Dkt. No. P2765/USW

18th September 2001

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 C.F.R. 1.56. I hereby claim foreign priority benefits under 35 U.S.C. 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed or, if no priority is claimed, before the filing date of this application:

Priority Foreign Application(s):

Application Number

9947404.7

Country

GB

Day/Month/Year Filed

26th July 1999

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below.

Application Number

Date/Month/Year Filed

I hereby claim the benefit under 35 U.S.C. 120/365 of all prior United States and PCT international applications listed above or below and, insofar as the subject matter of each of the claims of this application is not disclosed in such prior applications in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. 1.56 which occurred between the filing date of the prior applications and the national or PCT international filing date of this application:

Prior U.S./PCT Application(s):

Application Serial No.

Day/Month/Year Filed

Status: patented
pending, abandoned

PCT/GB00/02837

26th July 2000

PENDING

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon. And I hereby appoint **NIXON & VANDERHYE P.C., 1100 North Glebe Rd., 8th Floor, Arlington, VA 22201-4714, telephone number (703) 816-4000 (to whom all communications are to be directed)**, and the following attorneys thereof (of the same address) individually and collectively my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent: Arthur R. Crawford, 25327; Larry S. Nixon, 25640; Robert A. Vanderhye, 27076; James T. Hosmer, 30184; Robert W. Faris, 31352; Richard G. Besha, 22770; Mark E. Nusbaum, 32348; Michael J. Keenan, 32106; Bryan H. Davidson, 30251; Stanley C. Spooner, 27393; Leonard C. Mitchard, 29009; Duane M. Byers, 33363; Jeffry H. Nelson, 30481; John R. Lastova, 33149; H. Warren Burnam, Jr. 29366; Thomas E. Byrne, 32205; Mary J. Wilson, 32955; J. Scott Davidson, 33489; Alan M. Kagen, 36178; William J. Griffin, 31260; Robert A. Molan, 29834; B. J. Sadoff, 36663; James D. Berquist, 34776; Updeep S. Gill, 37334; Michael J. Shea, 34725; Donald L. Jackson, 41090; Michelle N. Lester, 32331.*

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FOR ADDITIONAL INVENTORS, check box ☐ and attach sheet with same information and signature and date for each.